Assessment of NGCC with CCS

Project Task Structure and NGCC-CCS Issues Overview

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WESTCARB Pre-Proposal Workshop
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What Do We Want to Learn?

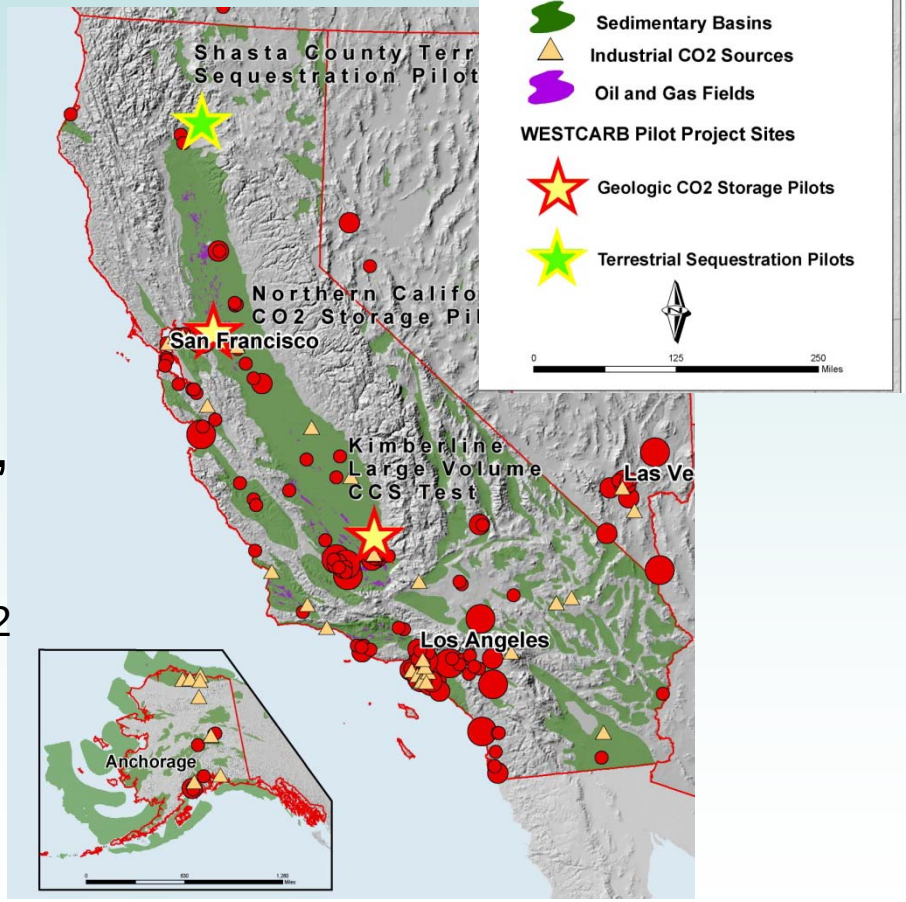
- WESTCARB has historically focused on CO_2 storage while acknowledging the importance of capture; new work aims to better understand capture issues for California's largest industrial source type—natural gas-fired combined cycle units
- Builds upon initial WESTCARB NGCC-CCS retrofit study by EPRI and contractor, currently under way
- What CO_2 capture technologies are the best candidates for application on NGCC power plants in California?
  - Retrofits to the existing fleet
  - New-build units
  - Location-specific challenges or goals, such as water availability/ quality, grid reliability initiatives, air quality improvement, etc.
  - Timeframe of application
- What are their cost, performance, and operational impacts?

What Do We Want to Learn? (cont'd)

- How many (and which) California generating units could be considered candidates for future CCS retrofit?
  - Supportive site/design characteristics for CO_2 capture
  - Dispatch mode (capacity factor, duty cycle) and remaining life conducive to economic justification
  - Reasonable options for CO_2 transportation and storage
  - Strategic or commercial factors
- Insight into "real world" issues gained by working with a major utility mapping (and implementing) a GHG/RPS strategy while remaining accountable to customers, employees, regulators, shareholders, etc.
- What is the best approach (and cost and leadtime) for testing a promising CCS application, at pilot-scale, on an NGCC unit or NG-fired cogeneration unit in California?

California NGCC Units and Potential CO_2 Sinks

- Approximately 50 F-Class (and a couple of H-Class) gas turbines have been commissioned in California since 1998
- With high capacity factors, some of these units are among the state's top CO_2 producers
- Generally in close proximity to CO_2 sinks



WESTCARB Seeks to Evaluate Capture Options by Multi-Level Engineering-Economic Approach

- Technologies for CO_2 capture from power plants are usually categorized by their point or method of application
  - Pre-combustion (e.g., steam methane reforming or partial oxidation of natural gas followed by catalytic water-gas shift and CO_2 separation via a regenerable physical or chemical solvent)
  - Post-combustion (e.g., regenerable solvent, such as an amine, ammonia compound, or amino acid, that removes CO_2 from flue gas in an absorber column and releases it upon addition of heat in a stripper column, with subsequent CO_2 purification if needed)
  - Oxy-combustion (e.g., use of an air separation unit and exhaust gas recirculation to produce an oxygen/flue gas blend that replaces air as the combustion medium, with subsequent CO_2 purification)
  - Membranes, solid sorbents, “frosting,” and other emerging technologies have potential application in multiple categories
- Candidate process review expected of engineering contractor, in conjunction with PG&E, LLNL, and Energy Commission

Challenges for CO_2 Capture from NGCC Plants

- The partial pressure of CO_2 in the exhaust gas stream is the driving force for most post-combustion capture processes, and the concentration of CO_2 in NGCC exhaust gas is low, typically 3–4% by volume
- Pre-combustion capture processes require significant heat and steam input (reforming) or reduce fuel energy content (partial oxidation)
- Oxy-combustion approaches involve costly and energy-intensive air separation units or not-yet-proven processes
- All processes add capital and operating expense, reduce net power output and/or boost fuel consumption, and increase cooling demand (and water use)

Task 1 Expectations

- Characterize the suitability of current and planned California NGCC facilities for possible CCS retrofit utilizing non-proprietary information and screening criteria developed in conjunction with PG&E and the Energy Commission
- Develop a list of viable CO_2 capture technology options, including development status, anticipated commercialization timeframe, and quantitative/qualitative cost and performance characteristics for NGCC (or cogeneration) plant application
- Compile an associated database/bibliography
- Identify regulatory and permitting requirements related to CO_2 capture, compression, transportation, and long-term storage
- Develop a Retrofit Engineering Options Analysis methodology

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Power Plant Siting
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- Distributed Generation
- AB 1632 Nuclear Assessment
- Greenhouse Gas Emission Impacts of Power Plants
- Siting Data Adequacy Forms

Power Plant Compliance
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- Emergency Peaker Projects

Information For Developers
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- Licensing Fees

Information For Public
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- Public Participation Guide

Environmental Protection
- Environmental Programs
- Once-Through Cooling
- Avian Guidelines for Wind Project Development
- Greenhouse Gasses

Engineering and Transmission
- Transmission Line Initiatives and Programs
- Strategic Transmission Investment Plan (PDF file)
- SB 1059 Transmission Corridors Designation
- 2005 EPAct Section 368 Federal Energy Corridors

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Alphabetical List of Power Plant Projects Filed Since 1996

- Renewable Energy Power Projects - (Proposed projects are listed on our 33% by 2020 page).

- Abengoa Mojave Solar Project - Mojave Solar LLC
- Almond 2 Peaking Power Plant Project - Turlock Irrigation District
- Avenal Energy - Avenal Power Center, LLC

- Beacon Solar Energy Project
- Black Rock 1, 2, and 3 Geothermal Power Project Major Amendment
- Blythe - Blythe Energy LLC
- Blythe II Combined Cycle - Blythe Energy LLC
- Blythe Solar Power Project - Solar Millennium LLC
- Blythe Transmission Line - Blythe Energy LLC
- Border - Calpeak (Emergency Peaker)
- Bottle Rock Geothermal - U.S. Renewables Group (Repower)
- Bullard Energy Center (BEC)

- Canyon Power Plant
- Carlsbad Energy Center - NRG
- Carrizo Energy Solar Farm
- Century - Alliance (Emergency Peaker)
- Chevron Richmond Power Plant Replacement Project - Chevron USA, Inc.
- Chula Vista Energy Upgrade Project - MMC Energy, Inc.
- City of Vernon Malburg Generating Station
- Colusa Generating Station (CGS)
- Community Power - Kings River Conservation District
- CPV Vacaville Station

- Delta - Calpine
- Drews - Alliance (Emergency Peaker)

- East Altamont - Calpine
- Eastshore Power Project - Tierra Energy
- El Centro Unit 3 Repower Project - Imperial Irrigation District (IID)
- El Segundo Repower - Dynegy/NRG
- El Segundo - Dry Cooling Amendment Proceeding
- Elk Hills - Sempra & Oxy
- Escondido - Calpeak (Emergency Peaker)

- Gateway Generating Station - PG&E
- Genesis Solar Energy Project - Genesis Solar LLC / NextEra™
- Gilroy I, Units 1,2 & 3 - Calpine (Emergency Peaker)

- Hanford - GWF (Emergency Peaker)
- Hanford Combined Cycle Power Project - GWF (Major Amendment)
- Henrietta Peaker - GWF
- Henrietta Combined Cycle Power Project - GWF (Major Amendment)
- High Desert - High Desert Power Project LLC
- Highgrove - AES
- Humboldt Bay Generating Station - PG&E
- Huntington Beach Unit 3 & 4 - AES
- Hydrogen Energy California - Hydrogen Energy International LLC

- Magnolia - SoCal Power Authority
- Malburg Generating Station - City of Vernon
- Mariposa Energy Project - Mariposa Energy, LLC
- Marsh Landing Generating Station
- Metcalf - Metcalf Energy Center LLC
- Modesto Irrigation District - Ripon, Simple Cycle
- (Abengoa) Mojave Solar Project - Mojave Solar LLC
- Morro Bay - Duke
- Moss Landing Unit 1 & 2 - Duke
- Mountainview - SCE

- Niland Gas Turbine Plant (SPPE)

- Oakley Generating Station (Formerly Contra Costa Generating Station)
- Orange Grove Energy, Simple Cycle
- Otay Mesa - Calpine

- Palen Solar Power Project - Solar Millennium LLC
- Palmdale Solar-Gas Hybrid - City of Palmdale
- Palomar Escondido - Sempra
- Panoche Energy Center - Energy Investors Fund
- Pastoria - Calpine
- Pastoria Expansion Project (Pastoria 2) - Pastoria Energy LLC

- Rice Solar Energy Project - Rice Solar Energy LLC / SolarReserve LLC
- Ridgecrest Solar Power Project - Solar Millennium LLC
- Riverside Energy Resource Center - City of Riverside Public Utilities
- Riverside Energy Resource Center Units 3 & 4 **(Expansion Project)** - City of Riverside
- Roseville Energy Park - City of Roseville
- Russell City - Calpine
- Russell City **Amendment** - Calpine

- Salton Sea Geothermal
- Salton Sea Geothermal Major Amendment - CE Obsidian Energy, LLC
- San Francisco Electric Reliability Project - City of San Francisco
- San Gabriel Generating Station - Reliant Energy
- San Joaquin Solar 1 & 2 - San Joaquin Solar LLC
- San Joaquin Valley Energy Center - Calpine
- Sentinel Energy Project - CPV Sentinel, LLC
- SMUD Combined Cycle Phase 1
- Solar One Power Project - SES Solar One LLC
- Solar Two Power Project - SES Solar Two LLC
- Southeast Regional Energy Center (Formerly City of Vernon)
- South Bay Combined Cycle - L.S. Power
- Starwood Power - Starwood Power-Midway LLC
- Sunrise - Texaco & Edison Mission E.
- Sun Valley Energy Project - Edison Mission Energy
- Sutter - Calpine

- Tesla Combined Cycle - FPL
- Tracy Peaker - GWF

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- Energy Commission News Releases

Colusa Generating Station (CGS) Power Plant Project

Docket Number: 06-AFC-09 (Application For Certification)

06-AFC-09C (Compliance Proceeding)

Committee Overseeing This Case:

James D. Boyd, Vice Chair
Presiding Member

Hearing Officer: Raoul Renaud

Key Dates

- 4/23/08 - Energy Commission approves project and issues license.
- 3/14/08 - Presiding Member's Proposed Decision is released.
- 11/30/07 - Final Staff Assessment is released.
- 8/01/07 - Preliminary Staff Assessment is released.
- December 13, 2006 - Commission accepts Application for Certification (AFC) as complete.
- November 6, 2006 - Application for Certification (AFC) filed with California Energy Commission

General Description of Project

On November 6, 2006, E&L Westcoast, LLC (E&LW), submitted an Application for Certification (AFC), to license and construct the Colusa Generating Station (CGS), electrical power plant project. The proposed project is in response to PG&E's Request for Offer (RFO) and a contract signed by E&LW and PG&E in 2006. This project will be reviewed under the 12-month Energy Commission siting regulations.

The proposed CGS would be a combined cycle power plant using Dry Cooling technology. The project will have a nominal electrical output of 660 MW with commercial operation planned by late spring 2010. The project will be fueled by natural gas delivered to the site via a new 8 inch, 1,500-foot pipeline owned and operated by PG&E. Transmission interconnection will require four (4) double circuit 230 kV lines that will connect to PG&E's existing 230 kV north-south transmission lines located approximately 1,800 feet east of the project site. Water for the project will be provided by the Glenn-Colusa Irrigation District via the Tehama-Colusa Canal, which is located to the west of the project site. The proposed water usage is estimated to be 126.1-acre feet annually and will use a Zero Liquid Discharge wastewater system. Air emissions from the proposed facility would be controlled using Best Available Control Technology with air pollution credits obtained from the Colusa County Air Pollution Control District.

The proposed project site would be located on 31-acres within a 100-acre site leased by E&LW. The site is within the Holthouse Ranch property 14 miles north of Williams and 4 miles west of I-5 in Colusa County, California, The legal description of this site is: Section 35, Township 18 North, Range 4 West, Mount Diablo Base and Meridian (Assessor's Parcel Number (APN) 11-040-024, Colusa County) The proposed CGS will be adjacent to PG&E's existing gas compressor station located west of Glenn-Colusa Bridge and Dirks Road.

Energy Commission Facility Certification Process

The Energy Commission is the lead agency under the California Environmental Quality Act (CEQA) and has a certified regulatory program under CEQA. Under its certified program, the Energy Commission is exempt from having to prepare an environmental impact report. Its certified program, however, does require environmental analysis of the project, including an analysis of alternatives and mitigation measures to minimize any significant adverse effect the project may have on the environment.

For Questions About This Siting Case Contact:

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Project Compliance Manager
Siting, Transmission and Environmental Protection Division
California Energy Commission
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Sacramento, CA 95814
Phone: 916-654-4842
E-mail: CMDavis@energy.state.ca.us

Announcement
Final Commission Decision

< Jan 2010 >

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Calendar
There Are No Upcoming Events Available

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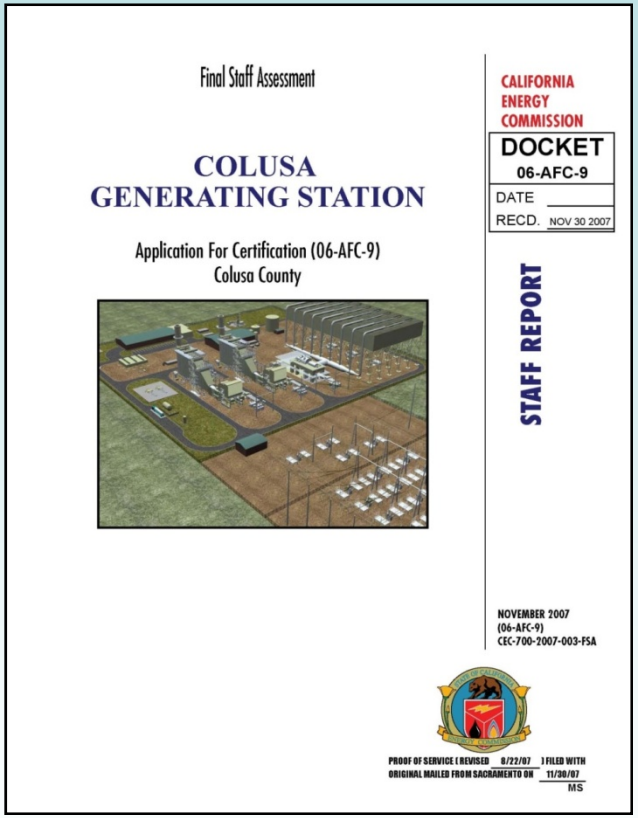
Example Plant Data Sources

- Plant layouts, turbine selections, cooling technology, water supply, and other details are available in documents on the Energy Commission website at *http://energy.ca.gov/sitingcases*.
  - The *Database of California Power Plants* provides a comprehensive list in spreadsheet form.
- EPA eGRID and DOE EIA databases provide unit-by-unit data on rated capacity, fuel consumption, CO_2 production, etc.
  http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
  http://www.eia.doe.gov/bookshelf.html


Final Staff Assessment

COLUSA GENERATING STATION

Application For Certification (06-AFC-9)
Colusa County

CALIFORNIA ENERGY COMMISSION
DOCKET 06-AFC-9
DATE
RECD. NOV 30 2007

STAFF REPORT

NOVEMBER 2007
(06-AFC-9)
CEC-700-2007-003-FSA

PROOF OF SERVICE (REVISED 8/22/07) FILED WITH ORIGINAL MAILED FROM SACRAMENTO ON 11/30/07
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Plot Plan from the Colusa Final Staff Report

PROJECT DESCRIPTION - FIGURE 5

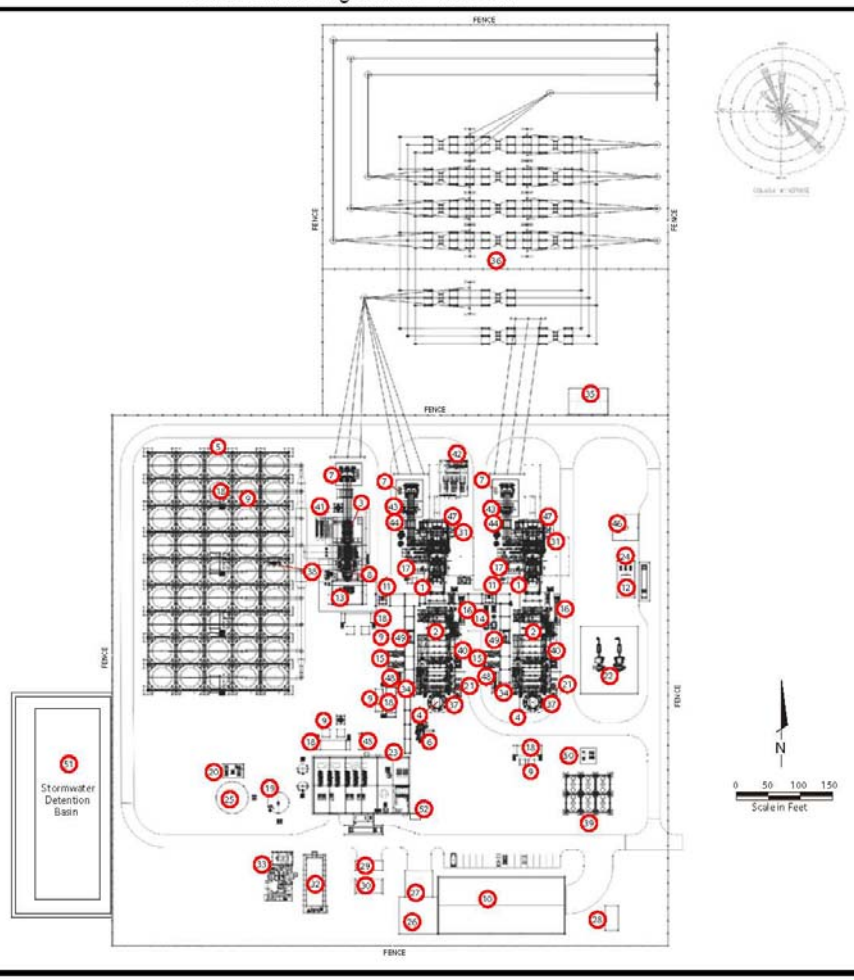
Colusa Generating Station - Plot Plan

NOVEMBER 2007

PROJECT DESCRIPTION

LEGEND

1 Combustion Turbine
2 Heat Recovery System Generator (HRSG) with SCR& Oxidation Catalyst
3 Steam Turbine Generator
4 HRSG Exhaust Stack
5 Air Cooled Condenser
6 Auxiliary Boiler
7 Main Transformers
8 Steam Turbine
9 Electrical Auxiliary Transformers
10 Control Room Administration, Warehouse, and Maintenance Bldg.
11 Area Sump
12 Ammonia Storage Tank
13 STG Lube Oil Skid
14 Air Compressors
15 Boiler Feed Water Pump
16 Fuel Gas Separator and Heating
17 GTG Support Skids
18 Power Distribution Center
19 Demineralized Water Storage Tank
20 Fire Water Pump Skid
21 HRSG Blowdown Tank and Sump
22 Gas Metering and Regulating with Fuel Gas Filter/Separators
23 Water Treatment Area
24 Ammonia Transfer Pumps
25 Raw/Firewater Tank
26 General Storage
27 Equipment Shelter
28 Septic Tank
29 Bulk Storage Building
30 Hazardous Waste Storage Area
31 CO_2 Bottles
32 Waste Water Basin
33 Water Evaporator Area
34 Pipe Rack
35 Switchyard Control House
36 230 kV Switchyard
37 CEMS Equipment Room
38 Condensate Tank and Pumps
39 Fin Fan Coolers
40 Ammonia Dilution Skid
41 Steam Turbine Electrical Equipment
42 Electrical Switchgear Building
43 Unit Auxiliary Transformer
44 Generator Breakers
45 Emergency Diesel Generator
46 Hydrogen Storage Area Tank
47 CT Air Inlet
48 Phosphate Feed Skid
49 Sample Panel
50 Auxiliary Cooling Water Pumps & Heat Exchanger
51 Stormwater Detention Basin
52 Oil/Water Separator



CALIFORNIA ENERGY COMMISSION - ENERGY FACILITIES SITING DIVISION, NOVEMBER 2007

SOURCE: AFC Figure 3.4-1

AB 1925 Analysis of CCS Costs (2007)

Estimated CO_2 Avoided Costs for New Facilities

	CO_2 Avoided Cost, $ per tonne			
CO_2 Source	PC	IGCC	NGCC	Fired Heaters
Cost Basis/Fuel	PRB subbituminous coal*	PRB subbituminous coal*	Natural Gas**	Fuel gas
U.S. Gulf Coast	46	34	65	64
California	54	42	73	72
California plus first-of-a-kind	55	47	76	74

*Reference or Basline is SCPC without capture with PRB coal

** Reference or baseline is NGCC without capture

Source: Katzer, J. and H. Herzog, *Economics of CO_2 Capture and Sequestration* and *Geologic Carbon Sequestration Strategies for California: Report to the Legislature (CEC-500-2007-100-CMF)*
.

Calculations of avoided costs with accounting for the California construction cost environment and first-of-a-kind contingencies. A metric tons are denoted as “tonne.”

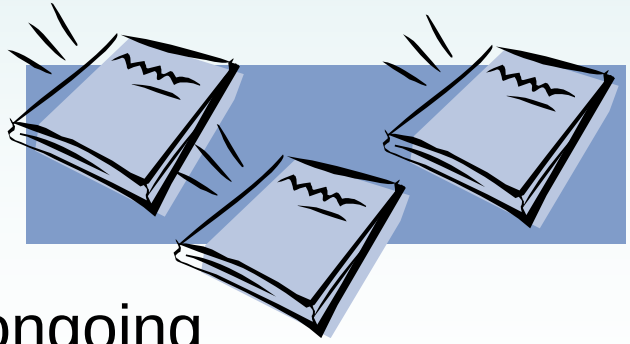
Task 2 Expectations

- Apply the Retrofit Engineering Options Analysis methodology to characterize California potential and identify site(s) for engineering-economic analyses
- Conduct engineering-economic analyses of CCS options (retrofit and new plant) for one or more California locations
- Work with LLNL on preliminary CO_2 storage site characterization, based on available non-proprietary data
- Examine site-specific permitting requirements and estimate time requirements

CCS Engineering-Economic Analyses: Trade-Off In Number of Cases vs. Level of Detail

- Need to determine level of detail required to assure confidence in CCS option cost and performance estimates and their value for strategic planning

- Then, determine how many (and which) cases to evaluate, and identify relative value of additional detail on a given case vs. evaluating more cases



- Phased, multi-level analytic approach may make most sense—ongoing discussion with PG&E and Energy Commission

"Strawman" Engineering Questions to Be Addressed

- For post-combustion CO_2 capture retrofits:
  - How to accommodate back-end equipment?
  - How to meet stripper reboiler steam loads?
  - How to address turbomachinery operational limitations and shaft "force balance" issues?
  - Is exhaust gas recirculation (EGR) to increase CO_2 concentration viable?
- For pre-combustion CO_2 capture retrofits:
  - For reforming, what are capture percentage limitations due to CO_2 in reformer heater exhaust?
  - What issues are involved in converting "DLN" (pre-mix) burners to diffusion flame for high-hydrogen fuel?

"Strawman" Engineering Questions to Be Addressed (cont'd)

- For new-build plants with CO_2 capture:
  - What new processes could be considered?
  - What are the opportunities for alternative configurations, heat integration, EGR, or other methods to reduce net power output and efficiency penalties?
- For all processes, what are operability impacts (i.e., start time/turndown, ramp rate, part-load performance, peak power augmentation capability, RAM, etc.)
- Are there "capture-ready" design measures that could be incorporated in new California NGCC plants (without CO_2 capture) to facilitate later conversion to CCS operation?

Task 3 Expectations

- Working with PG&E, the Energy Commission, LLNL, and potentially other site hosts, select a CO_2 capture technology type, location, and storage approach to test integrated NG-CCS at pilot or pre-commercial scale
- Develop a “pre-FEED type” site-specific preliminary engineering design, cost estimate, and schedule
  - Adapt/develop process flow diagrams, heat and mass balances, equipment layouts, bulk material quantities, emissions, and other information, within project resources
  - Identify permitting requirements (surface and subsurface) and expected timetable
  - Develop a Gantt chart showing major tasks and dependencies for detailed design, procurement, and construction

Voices from Around the World Are Clear—

WESTCARB's NGCC-CCS Assessment Supports the Goal

Multiple Large-Scale CCS Demonstrations with Pre-, Post-, and Oxy-Combustion Technologies in Different Geologies Are Needed ASAP